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Midwest Research Inst, Kansas City, Mo.

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CHEMICAL TECHNOLOGY AND ECONOMICS IN ENVIRONMENTAL PERSPECTIVES

TASK II - INVESTIGATION OF ALTERNATIVES TO CHLOROFLUOROCARBONS IN SELECTED AEROSOL PRODUCTS

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF TOXIC SUBSTANCES
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CHEMICAL TECHNOLOGY AND ECONOMICS IN ENVIRONMENTAL PERSPECTIVES

Task II - Investigation of Alternatives to Chlorofluorocarbons in Selected Aerosol Products

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This report has been reviewed by the Office of Toxic Substances, Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency. Mention of trade names or commercial products is for purposes of clarity only and does not constitute endorsement or recommendation for use.

PREFACE

This report presents the results of Task II of a project entitled "Chemical Technology and Economics in Environmental Perspectives" performed by Midwest Research Institute (MRI) under Contract No. 68-01-3896 for the Office of Toxic Substances of the U.S. Environmental Protection Agency (EPA). Mr. Charles M. Auer was the project officer for EPA.

Contributors to portions of this task were Dr. Thomas W. Lapp, Mr. Gary L. Kelso, Mr. Howard Gadberry, Mr. Fritz Hoffmeister, and Mr. Richard Welch. Dr. Lapp is project leader for this contract. This report was prepared under the supervision of Dr. Edward W. Lawless, Head, Technology Assessment Section. This program has MRI Project No. 4441-L.

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Approved for:

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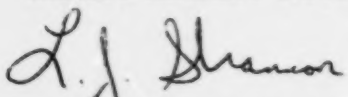

L. J. Shannon, Director
Environmental and Materials
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March 1978

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SECTION 1

INTRODUCTION

In October 1976, an interagency workgroup (comprised of representatives from the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the Consumer Product Safety Commission (CPSC)) initiated examination of regulatory options for controlling the environmental release of certain halocarbon compounds that pose a threat to stratospheric ozone. The initial concern of the work group was primarily with the use of fully halogenated chlorofluoroalkanes as aerosol propellants. Several specific aerosol propellant applications, as well as some other related applications, were brought to the attention of the work group by interested parties as possibly being "essential uses" of these substances. The purpose of this task was to investigate these applications to identify the available and technologically feasible alternatives and, to the extent possible, examine the cost factors associated with these alternatives.

It is emphasized that the determination of the essentiality of these products for regulatory purposes was <u>not</u> to be made by MRI in this task. These determinations were, and are being, made by the workgroup using the information generated here as well as information made available to the workgroup from other sources.

SECTION 2

SPECIFIC PRODUCT TYPES

This section presents an analysis of each of 13 specific aerosol product types that use chlorofluorocarbons. Information provided for each product type includes a general description, its utility, alternatives to it, and a brief analysis of the economic aspects of the alternatives or lack of alternatives. Within the product description and utility, data are presented for which chlorofluorocarbons are utilized, their primary and/or secondary functions, specific characteristics contributed to the product by the chlorofluorocarbons, consumers of the product, and the amount of chlorofluorocarbon used annually in the product. The alternatives portion provides a discussion of alternative propellants for aerosol products, nonaerosol methods for delivering the same goods or services, and the availability of each of the alternatives. Economic aspects were limited to the impact of the alternative delivery method on the consumer or user of the product and any impacts resulting downstream from the consumer or user.

AGENTS FOR LATENT FINGERPRINT DEVELOPMENT

Product Description and Utility

Chemical reagents are applied primarily for latent fingerprint development on porous and absorbent surfaces (e.g., paper, cardboard, unfinished wood, etc.) or on slightly textured surfaces (e.g., book covers, some plastics, etc.). Special fingerprint powders are most effective when applied to smooth, nonabsorbent surfaces (e.g., glass, metal, painted surfaces, etc.) and are generally preferred to disclose fresh latent prints at the crime scene.[1-5] The chlorofluorocarbon propelled products comprise two basically different chemical agents for print development and two agents for the removal of unwanted stains caused by the developing agents. These products are ninhydrin, silver nitrate, ammonia, and mercuric salts.

Ninhydrin--

This reagent is typically used as a 0.6% solution in acetone[6] or petroleum ether.[7] When the reagent is packaged as an aerosol spray, F-12 is normally the propellant. Mixtures of F-11 and F-12 have been employed if the reagent is contained in a glass aerosol spray bottle.[7,8] Ninhydrin solution may be sprayed or brushed on, or the document may be dipped into the solution.[6] While the essential requirement is to obtain a uniform and complete coverage of a surface, some experts state that best results are obtained if a surface is lightly but visibly wet,[8,14] but others state that a fine spray should be used with as little wetting as possible.[7,15] At the present time, ninhydrin is the agent of preference for developing latent prints on paper and other porous surfaces.[7,9,10,12,14]

Silver Nitrate--

The use of silver nitrate is declining[9,12] and currently is regarded as an agent of last resort.[1] It is employed only when large amounts of evidence are to be processed.[7,14] Silver nitrate solutions are used in several different formulations including aqueous solutions of 3 to 5%[3,6] or 10%[6,7] concentration, ethanol solutions,[6,16] or acetone solution[4] with sufficient water added initially to dissolve the silver nitrate crystals. The silver nitrate reacts with chloride deposits remaining in latent fingerprints, but it also reacts with traces of chloride found naturally in papers and other substances to produce a background that reduces print contrast and the clarity of the evidence.[1,3,4] Silver nitrate also has the limitation that it is useful only for developing prints no more than 6 months old.[4] Only one company is believed to supply silver nitrate reagent packaged as a chloroflurocarbon (F-12) propelled aerosol.[7,16,17]

Stain Removers--

Aerosol formulations of stain removers include ammonium hydroxide for ninhydrin stains[6] and mercuric nitrate[6] or mercuric chloride[4] for silver nitrate stains. Only one supplier is known to offer aerosol dispensed stain removal sprays using chlorofluorocarbons as the propellant.[16]

The F-12 employed for both the print developers and stain removers serves only as a propellant except when ninhydrin is used in conjunction with petroleum ether or acetone; in these instances, the F-12 also serves as a secondary solvent for the reagent.[7] Stain removers, silver nitrate, and ninhydrin are also available as a spray container fitted with an external propellant.[16]

Little or no use of chemical developers is made at the crime scene by officers conducting the search for physical evidence.[9,10,13,14,18] In contrast to the use of powders, chemical development of latent prints is best performed in the laboratory and physical evidence is carefully removed to the laboratory where it is processed.[10,14] Over 90% of all print spraying in the laboratory is estimated to be done in ventilation hoods.[7] Laboratories processing fairly large amounts of evidence seldom use the aerosol products, relying instead on sprayers using a source of compressed gas.[10,14,18] A national laboratory stated that they used aerosol containers of ninhydrin only for touch-up, to enhance the contrast of a previously sprayed print.[14]

The two largest distributors of F-12 propelled aerosol fingerprint sprays have a combined annual output of about 40,000 units.[7,19] Unit sizes range from 2 to 16 oz. The total annual consumption of F-11 and F-12 is estimated to be approximately 3,500 to 4,000 lb.[7,19]

There would be no known impact on environmental quality or human health and safety resulting from the removal of this product from the market. Public safety, as influenced by law enforcement and criminal prosecution, can be adequately served through the use of alternative methods.

Alternative Products or Systems

As indicated previously, all of the reagents currently supplied in aerosol form are feasibly applied by other means. Although the prepackaged sprays do represent a convenient and quickly usable form of these products, the substantial majority of latent fingerprint development does not rely upon aerosol products.

Silver nitrate solutions present problems for the selection of aerosol propellants other than F-12. Some current silver nitrate sprays utilize an external F-12 container in conjunction with an atomizer bottle.

Hydrocarbon Propellant--

The most logical choice for an alternative propellant for ninhydrin would be a hydrocarbon mixture. Because of the high degree of flammability of the reagent carrier (e.g., acetone, petroleum ether, etc.), the flammability of a hydrocarbon propellant may not create additional problems (although the chlorofluorocarbon has some flame retardant properties). A major custom aerosol packager advises that no technical problems should occur in substituting hydrocarbon propellants for F-12 when either acetone or ether is used as the primary solvent for ninhydrin.[20] Spraying is normally conducted by trained laboratory personnel using properly ventilated laboratory hoods so that the flammability aspect should be minimal. Hydrocarbon propellants would have no known reaction or adverse effect on ninhydrin. Testing of this propellant system should be conducted since the influence of spray droplet size and spray characteristics may have an effect on sensitivity.

Carbon Dioxide--

The use of impact-filled carbon dioxide, in conjunction with either methylene chloride or 1,1,1-trichloroethane, as a propellant for ninhydrin may be acceptable.[7] However, ninhydrin is quite sensitive to pH and either carbon dioxide or its acidic products might adversely affect the stability of the reagent; also the coarser spray produced by carbon dioxide may affect the sensitivity of the ninhydrin.

Nonaerosol Sprays--

Both ninhydrin and silver nitrate can be effectively sprayed using widely available equipment. Because of the large volume of reagent consumed, the Federal Bureau of Investigation (FBI) uses commercial paint spray guns for ninhydrin.[14] For departments using small quantities of reagent, it would be necessary to insure that solutions were either freshly prepared or properly protected. The advantage cited for the use of freshly prepared solutions include better results,[9,14] greater control over spray patterns,[10,18] greater reliability,[8,10,14] significantly lower cost,[9,10,18] and the ability to use precision, all-glass sprayers.[10]

For portable spraying in the field, rubber squeeze bulb sprayers can be used where a limited area is involved. Atomizers sold for nasal and throat sprays generally provide a very coarse spray that is difficult to control.

Where freedom from contamination and absolutely no reaction with sprayer parts is essential, precision, all-glass sprayers can be used for either laboratory or field use.[21] These glass sprayers are available from several suppliers[22] and are widely employed in dispersing developing reagents on paper chromatograms, etc. They are available in several spray sizes, including ultra fine sprays. If a true aerosol of ultra fine droplet size is desired, the all-glass nebulizer can be used.[21]

Economic Considerations

The use of hydrocarbon propellants should have little or no economic impact on the consumers of these products. If aerosol packaging of fingerprint sprays was completely discontinued, the impact would be felt primarily by smaller law enforcement agencies having limited laboratory facilities. Costs would be associated with the training of technicians to prepare bulk solutions and the purchase of spray equipment. In addition, an air compressor and air line filter/dehydrator would be required unless compressed gas cylinders can be utilized. If it is assumed that a ventilation hood is already available (it should be in use even if aerosol sprays are employed), the total cost of laboratory glassware, chemicals, and spraying equipment could be from $250 to $500/agency. However, the use of bulk chemicals rather than aerosol sprays is more cost effective so that an eventual cost savings should result.

ANTI-SPATTER COMPOUNDS FOR WELDING

Product Description and Utility

Spatter is molten metal thrown out of the arc pool in the elctric arc welding process. When cool and on an untreated surface, spatter can usually be removed only by hand grinding or mechanical means.

Anti-spatter compounds are formulations which are designed to prevent spatter from adhering to surfaces. These surfaces include areas on a workpiece adjacent to a weld, jigs, and fixtures of a welder, and nozzles and tips of wire welders and MIG guns.[23-28] After a weld is completed, the anti-spatter product is removed by wiping, water rinsing, or air blasting from an air hose.

One special application of anti-spatter compounds essentially requires spraying of the material. This use involves treatment of the nozzles or tips of MIG welding guns or wire welders to prevent spatter from adhering to the tip (inside and outside) and thereby interfering with the flow of shielding gas.

Several suppliers offer an aerosol packaged spray for nozzles and tips.[23,27-30] These sprays are particularly useful in directing the coating up into the inside of the welding gun tip as well as coating the outside of the nozzle. Several of these aerosol products are conspicuously labeled: "Contains no Fluorocarbons,"[29,30] or "Contains no Fluorocarbons or Hydrocarbons."[31] The industry is conscious of the desire to restrict fluorocarbon usage, and it appears that alternative propellants have been found to be satisfactory for certain types of anti-spatter products.

Anti-spatter compositions are usually one of three types. These are: (a) inorganic or mineral solids; (b) resins and soaps; and (c) resins or gels containing silicone fluids or greases.

At the present time it appears that only one product that is sold directly to users employs F-12 as the propellant.[32] In this product the primary function of the F-12 is as a suspension carrier. Its propellant properties are a secondary function. In the formulation, methylene chloride is also added to decrease the internal pressure.[32] Since F-12 has a boiling point of about -30°C, this particular formulation could not retain the use of F-12 as a carrier and be applied by means other than an aerosol. Reformulation of this product with other solvent carriers (including other chlorofluorocarbons) for application by other techniques (e.g., brushing) have not been attempted.[32] The

active ingredient of this proprietary anti-spatter product consists of a finely dispersed mineral solid suspended in the F-12 carrier/propellant. The product is sprayed onto an area, and the weld made immediately through the film of anti-spatter.[32] Drying time for the spray is typically 5 to 10 sec.

This product is packaged in 16 oz aerosol cans, of which 33% is F-12.[32] Approximately 12,000 cans are used annually.[32] MRI estimates that about 5,000 lb of F-12 are used per year in this product type.

There should be no impact on environmental quality or human health and safety associated with the removal of this product without replacement by an alternative.

Alternative Products or Systems

A suitable alternative for F-12 in this product line must have suitable properties as a propellant and as a carrier. An acceptable carrier should fulfill the following technical requirements.[32]

* The carrier must wet metal surfaces well, even when contaminated with oil, grease, rust preventives, etc.

* The fine dispersion of mineral must be maintained without agglomeration or serious caking.

* The carrier should dry quite readily when sprayed onto the metal surface (less than 30 sec).

* The carrier should not corrode the metal or the can.

* The carrier must present a minimal hazard to the user.

The producer states that numerous solvents and carriers have been considered as a replacement for F-12 because use of a replacement would considerably reduce the cost of the product.[32] None of the replacements have been successful.

Several anti-spatter compounds use water as the carrier.[29,30] DuBois states that water is not suitable for its product because, even with wetting agents, the aqueous mixture does not evenly wet grease or oil-contaminated metallic surfaces.[32] The use of water also increases the drying time to between 5 and 10 min.[29,32]

Early in 1976, DuBois attempted to substitute a combination of methylene chloride and carbon dioxide for the F-12 propellant/carrier. This reformulation proved unsatisfactory because of severe settling and agglomeration of the mineral. Severe plugging of the aerosol valve was experienced. After several months the product had become so caked that it could not be redispersed on a paint shaker.[32]

Hydrocarbon propellants present a flammability and explosion hazard. Use of a flame retardant might be able to reduce a hydrocarbon-propelled spray from a category of "Extremely Flammable," down to "Flammable," but it is doubtful that the hazard could be totally eliminated. The use of chlorinated or brominated minerals is considered undesirable because chlorinated hydrocarbons may, under welding conditions, form harmful vapors and gases.

Other possible alternatives include water-based concentrates (similar to other anti-spatter products[29,30]) which are diluted with tap-water before being brushed or pressure sprayed onto the work, resinous materials in a solvent base (typically 1,1,1-trichloroethane or methylene chloride) designed to be brushed or sprayed onto the metal and having the characteristic of fast drying, and jellies or pastes which can be applied to the work but are so widely used for nozzles and tips that they are generally called "tip dips." These are stated not to be viable alternatives with the DuBois formulation.[32]

Aerosol packaged products using carbon dioxide as the propellant are available[23,27,28,30] for formulations such as the water-based concentrates and the resinous materials in a solvent base (e.g., 1,1,1-trichloroethane or methylene chloride). These products offer the ability to direct the spray into the inside of the welding nozzle. In rare cases they are sprayed on the work that is to be welded.

Most welders and producers of most anti-spatter products consider aerosol sprays to be prohibitively expensive to use for coating most work to be welded. Welders continue to use aerosol sprays on gun tips, but they prefer to apply anti-spatter to the base metal by brushing, wiping, or spraying from an air line gun. The DuBois anti-spatter is several times more expensive than other anti-spatter compounds. The maker believes that the reluctance of users to switch to much cheaper products provides evidence that the product is viewed favorably on a cost/effectiveness basis.[32]

The options that appear at present for the specific formulation under consideration are limited to either complete reformulation of the anti-spatter compound with sacrifices in drying time and performance or withdrawal of the product from the market.

Economic Considerations

If the product is redeveloped either as an aerosol or a bulk compound for conventional application to the work, the impact on users would be reflected in some increased costs due to slower welding and spatter removal times.

If the product is discontinued, the greatest impact would be on those users involved in welding of products where surface appearance is important, not on welders of plate or structural alloys. Since users must believe that each dollar spent for anti-spatter saves more than one dollar in total welding costs, the impact can be estimated as some multiple of present expenditures on this product. For 12,000 units at $3.50 each, a cost multiplier of three suggests impacts on the order of $125,000/year associated with nonavailability of this product. The increased costs of welded products would be passed on to consumers.

The direct consequences to DuBois if this product could not be produced would reflect lost sales of less than $50,000/year. Commissions earned by 500 to 600 sales representatives would be slightly reduced.[32/]

AEROSOL SPRAY TO PRODUCE SMOKE OR FOG

Product Description and Utility

The common name used in industry for this aerosol product is "Fog Juice." The composition consists of a mixture of F-12 and light mineral oil in approximately 50/50 proportions.[33] It is packaged in 16 oz containers commonly called "Pressure Packs." Rather than using spray nozzles, the containers are equipped with a connector similar to that on a tire inflation hose.[34] The fog effect is produced when the fine spray of oil and F-12 from the Pressure Pack comes into contact with an electrically heated hot plate. The oil is vaporized and becomes smoke. Depending on the type of scene being created, the audience sees either smoke or fog. The "Fog Juice" is used in the production of stage shows, television shows, motion pictures, etc.[33,35,36]

The quantity of F-12 propelled product used each year is approximately 1,500 16-oz containers.[34] Since the compound is approximately 50% F-12, the use of the compound results in the release of approximately 750 lb/year of chlorofluorocarbon. The total usage is very small since one can will provide 30 min of smoke, and most smoke or fog scenes only require smoke generation for 10 to 15 sec.[34-36] The two major distributors of this F-12 propelled product are Mutual Hardware Corporation located in New York and the Aztec Company located in Florida.

The chlorofluorocarbon propelled spray permits the use of a compact equipment package, not requiring an air compressor. The smoke generators equipped with "Pressure Packs" can be remotely operated thereby permitting easier stage settings and fewer people to operate the machine.

The F-12 propellant is soluble in the hydrocarbon oil and therefore is capable of establishing a fairly constant vapor pressure within the container. The constant pressure is a benefit to regulating the quantity and quality of spray desired.

No information was obtained indicating that harmful by-products are formed from the F-12 when it is in contact with the heated surface of the smoke generator. The distributors of the smoke generators contend that the machine should be used with adequate ventilation.[35] The primary danger quoted from use of the machine is that panic situations could arise in crowded areas if some members of the crowd thought that the generated smoke was the result of an actual fire.[35] This situation could exist whether or not the chlorofluorocarbon propellant was used in the smoke generation.

The removal of this product without replacement by an alternative would generally have no known impacts on environmental quality, human health, and safety.

Alternative Products or Systems

Nonaerosol Fog Generator--

This type of machine has been in use for over 50 years and does not require the use of propellant gases.[35] The machine uses light weight mineral oil and produces smoke from the use of heat and the conversion of water into steam. The use of an air compressor or manual pump is required to spray the heated oil into the smoke generating area. Dry ice can be used with the machine to create special density effects with the generated smoke.

Dry Ice--

In some instances dry ice has been used in theatrical, movie and television productions to simulate the effect of smoke or fog.[36] The vapor produced by the dry ice is difficult to disperse and may limit the degree to which special effects are obtainable.

Carbon Dioxide--

Impact-filled carbon dioxide should be an acceptable propellant system provided that the coarser spray pattern does not substantially affect the desired results. Sprays of light lubricating oils, consisting of a mixture of hydrocarbons, commonly use this propellant system. It appears reasonable to assume that with some reformulation, this propellant should also be applicable to the light weight mineral oil used in this type of product.

Other Compressed Gases--

Industry sources indicated that compressed gases such as nitrogen, air, nitrous oxide, etc., are not presently being used in the industry.[34,36] The solubility of the gases in the oil would probably be very small and therefore cause the pressure of the can to decrease by a factor of 3 to 4 from the time the can is put into service up to the point where insufficient pressure is available for proper operation.

Hydrocarbon Propellants--

This product is not commonly packaged with a hydrocarbon propellant. The primary reason for not using hydrocarbons is related to the safety factor involved in filling cans with a flammable propellant. The chlorofluorocarbon propellant was selected by the supplier because of the positive safety factors and the increased costs to the manufacturer associated with equipment changes, insurance, etc., when using hydrocarbons.[33] Since the fog machines using pressurized containers were designed for the F-12 propellants, additional testing would be necessary to establish any smoke machine equipment changes required, the shelf life of the pressurized container, and the smoke characteristics or effects possible when using hydrocarbon propellants.

F-22 Propellant--

If available, this chlorofluorocarbon would be an acceptable alternative. No problem would be anticipated in converting from F-12 to F-22 for this product.

Economic Considerations

At the present time a 16-oz container of this product sells for approximately $4.50. Since the manufacturing costs are about 25% of the retail price, the use of an alternative propellant system should generally have little effect on the production cost or on the retail price.[34/]

Carbon Dioxide--

If this propellant would prove to be acceptable, the resultant product should prove to be advantageous to the consumer. The current product employs 50% F-12 whereas with impact-filled carbon dioxide products the propellant normally represents only approximately 5 to 10% of the total contents.[37/] However, the cost of the packaged system should probably remain about the same since the decrease in propellant content is balanced by an increase in light mineral oil content. Costs due to any change in filling equipment by the manufacturer would likely be passed on to the consumer.

F-22 Propellant--

If available, the use of F-22 in a propellant formulation should require no changes for the manufacturers and consumer prices should remain essentially the same as for the F-12 propelled product. A low cost pressure depressant is normally used with the higher cost F-22 so that the total cost of the propellant system is about the same as that for F-12.

SPRAY MOLD RELEASE AGENT FOR MEDICINE TABLETS

Product Description and Utility

The product under consideration is actually not a mold release agent for medicine tablets but rather a Teflon® solid lubricant sprayed onto selected external moving parts of a tablet machine.[38] Rotary type tablet machines have multiple stations of punches and cams to compress the powder into tablet form. This particular product is used primarily to lubricate the upper punch shafts or barrels and the socket or guide sleeves of the lower punch. Other products (e.g., high melting, extreme pressure greases) are used to lubricate the rotary heads and other parts. Grease formulations are not acceptable for the punches because, as the shaft moves up and down, the grease tends to migrate to the bottom of the punch and collect a dust of the powdery tablet material. This buildup will eventually flake and drop down into the material being pressed into the tablet, resulting in a contaminated product. The Teflon® product resists this downward migration and eliminates the contamination potential.

This aerosol product consists of an ultra-micron size Teflon® in methylene chloride carrier and propelled by F-12.[1] Approximately 50% of the formulation is F-12. From information supplied by the manufacturer, it is estimated that approximately 4,500 lb of F-12 are consumed annually for this product.[38] The F-12 is used solely as a propellant in this product. Numerous other Teflon® solid lubricant products are available in aerosol containers; however most, if not all of them, contain binders which are not suitable for this application.[38]

The removal of this F-12 propelled product from the market would have no adverse impact on environmental quality or human health or safety.

Alternative Products or Systems

Alternative methods for the application of solid lubricants have been described in a previous report.[37] A brief discussion is given below for some of these methods as they apply to this particular situation.

Hydrocarbon Propellants--

This propellant system would be a suitable alternative except for the flammability potential. The manufacturer states that most pharmaceutical producers do not like to employ flammable materials in their production facilities.[38]

Carbon Dioxide--

Impact-filled carbon dioxide should be a suitable alternative propellant system. However, the manufacturer has not requested the contract filler to

attempt this method. This system has been utilized for other similar products so that no problems should be incurred in the formulation of this aerosol product.

Brush Application--

This method is commonly used by many pharmaceutical manufacturers for lubricating tablet machines.[38] Powdered Teflon® is mixed with a suitable carrier (e.g., methylene chloride) and applied by brush prior to machine startup. The method is somewhat messy and usually results in a coating rather than the thin film obtainable from an aerosol product. However, no operating problems seem to be incurred by this method.

Economic Considerations

The economic aspects of the alternative methods of application have been treated in a previous report.[37]

LEATHER SPRAY POLISH PRESERVATIVE

Production Description and Utility

This product is a proprietary formulation of a viscous liquid which is applied to raw leather goods for preservation. It is manufactured by ACA Corporation, Brooklyn, New York, Jim York Chemical Company, Houston, Texas, and other small companies. The product is supplied in both drums and aerosol cans to manufacturers, wholesalers, and retailers of leather goods such as saddles, boots, belts, and shoes. The drummed product is offered to larger manufacturers using high volumes of the preservative and is typically applied from a paint spray type apparatus with a high pressure spray device. Companies and shops that use smaller volumes purchase the product is aerosol cans (16 oz) and apply the preservative as an aerosol spray.

The aerosol product uses F-12 as a propellant. The preservative is a viscous liquid, and the F-12 serves to propel the preservative onto the leather in a finely divided aerosol spray. Application in this manner provides a uniform wetting of the leather surface.

This product is used by both industrial and commercial firms as well as individual consumers. About 75% of the market is in the industrial/commercial sector and the remaining 25% is in the consumer sector. Annual sales of the aerosol cans by Jim York Chemical Company are 20,000 cases of 12 units each or about 240,000 units/year. This company produces an estimated 20% of the total sales volume, so the total annual sales of the industry is about 1,200,000 units.[39/] Each unit contains 7 fluid ounces of F-12, so that the total annual consumption of F-12 is about 8.4 million fluid ounces (716,700 lb).

Removal of this product from the market without replacement by an alternative would have no adverse impacts on environmental quality, human health, or human safety.

Alternative Products or Systems

Hydrocarbon Propellants--

A spray leather preservative is commercially available as an aerosol product with a hydrocarbon propellant.[39/] The use of hydrocarbon propellants may create some safety risks because of increased flammability. The degree of risk would depend upon the conditions under which the product is used. The use of a hydrocarbon propellant results in an otherwise acceptable product.

Carbon Dioxide--

Impact-filled carbon dioxide is compatible with the other components of this system and could be used as a propellant system. Its usage would result in a more coarse spray than that obtained with either hydrocarbons or F-12.

One manufacturer stated that the use of carbon dioxide would produce a sufficiently coarse spray that the product may not be competitive with products using hydrocarbon propellants due to decreased area coverage per unit weight of product dispensed.[39/]

F-22 Propellant--

If available, this chlorofluorocarbon should be an acceptable alternative. No problems would be anticipated in the conversion from F-12 to F-22 for this product.

Mechanical Pump Sprayer--

A mechanical pump spray system equipped with a trigger spray device would be an acceptable alternative. Some leather preservatives are available in less viscous liquid formulations which are applied manually with a cloth, sponge, etc., or sprayed with a mechanical pump sprayer.[39/] High volume consumers use a pressurized spray system, such as a paint spray apparatus or a compressed air hand sprayer similar to those used for pesticide application, and do not employ individual aerosol cans except in specialized instances.

Economic Considerations

The use of a hydrocarbon propellant should present no increase in cost to the consumer since these products are commercially available at a competitive cost.

Mechanical pump sprayer should present little, if any, overall increase in consumer costs. If a trigger spray system is used, a slight initial cost may result due to the pump sprayer, but subsequent product could be purchased as a refill at a lower cost. The net result should be little or no increase in costs to the consumer.

The use of carbon dioxide as a propellant system should not result in increased consumer costs. Costs of conversion of the F-12 filling systems to carbon dioxide systems probably would not be passed on to the consumer since this aerosol product would compete with the hydrocarbon propelled products currently on the market.

HIGH VOLTAGE SPRAY INSULATION

Product Description and Utility

This product consists primarily of a heavy acrylic used entirely by the industrial sector (primarily electronics firms) as an insulation material to prevent corona in high voltage circuits.[39] One of the principal uses is in television repair.[40] The acrylic is propelled from the container by F-12, whose sole function is that of propellant.

Chemtronics, Incorporated is the major producer of this relatively low volume product.[40] The total annual sales volume for the entire market of this product is estimated to be 20,000 to 30,000 units per year.[40] This corresponds to a total F-12 annual consumption of approximately 6,200 lb.

The removal of this product from the market without replacement by an alternative would have no adverse impacts on environmental quality, but removal could place humans at risk from the corona developed in high voltage circuits.

Alternative Products or Systems

Alternative delivery systems must be capable of dispensing the acrylic such that a thin, uniform layer is applied. Upon drying, the resultant film should provide an even, pinhole-free coating to the parts.

Hydrocarbon Propellants[40]--

The major producer of this product has successfully formulated and tested an aerosol using a hydrocarbon propellant system. Present acrylic formulations, excluding propellants, are flammable. Use of a hydrocarbon propellant will increase the flammability of this product. No significant additional problems are anticipated in view of the current precautions stated for the use of this product. Chemtronics planned to convert its product to this propellant in January 1978.

Carbon Dioxide[40]--

This propellant system has been tested and found to produce an uneven dispensing pattern which resulted in the formation of an uneven film. Test results showed this product to be unacceptable for its intended purpose.

F-22 Propellant--

If available, this chlorofluorocarbon would likely be an acceptable alternative. No problems would be anticipated in the reformulation of the acrylic to accommodate the use of this propellant.

Economic Considerations

The use of the hydrocarbon propellant system will not result in any appreciable increased costs to the consumers.[40/]

If available, the use of F-22 in a propellant formulation should require no changes for the manufacturer and consumer prices should remain essentially the same as for the F-12 propelled product. A low cost pressure depressant is normally used with F-22 so that the total cost of the propellant system averages to approximately that for F-12.

CLIPPER COOLANTS AND LUBRICANTS

Product Description and Utility

Aerosol clipper coolants and lubricants are utilized by veterinarians and animal groomers to cool, lubricate, and, in one case, to sanitize the blades of electric clippers before hair removal from a variety of animals. Although a number of different companies manufacture and market products that are designed to fill this need, the formulations are similar. A typical formulation contains an oil base, a solvent carried lubricant (a silicone or 1,1,1-trichloroethane), isopropyl alcohol, and the propellant. In the majority of products the propellant is approximately a 50:50 mixture of F-11 and F-12.[41] One manufacturer adds a quaternary ammonium compound to improve the disinfectant quality of the product.[42] Clipper coolants and lubricants are marketed in 6-, 14-, 15- and 16-oz spray cans.

F-11 and F-12 function primarily as a propellant system. A secondary function of the F-11 is as a solvent. A waxy, greasy material composed primarily of body oil residues is deposited between the blades of the clipper during the clipping process.[43] Due to the close juncture of the cutting blades, this deposit tends to increase friction (thus increasing the temperature of the blades) and decreases the cutting efficiency resulting in an increased pulling of hair. In addition to its use as a wetting agent and pressure depressant, the F-11 serves to dissolve this waxy buildup.[43]

Until approximately August 1977, all manufacturers had been using the F-11 and F-12 propellant system. Currently two manufacturers are in the process of altering their propellant system.[44,45]

One industrial source estimates that the total market for this product line is approximately 400,000 standard units (16-oz cans) per year.[41] Depending upon the manufacturer contacted, chlorofluorocarbons comprise anywhere from 94 to 98% of the product. Based on these data, and assuming 95% propellant content, approximately 6.5×10^6 fluid ounces of F-11 and F-12 are consumed yearly. If the propellant is equally divided between F-11 and F-12, then about 2.6×10^5 lb of F-12 and 2.9×10^5 lb of F-11 are used per year in the manufacture of this product line.[46]

The removal of F-11 and F-12 as the propellant system without replacement by an alternative should have no known detrimental impacts on environmental quality and/or human health and safety.

Alternative Products or Systems

Alternative propellant systems which substitute other propellants directly for chlorofluorocarbons exist, and several manufacturers are in the process of

converting to other systems. Properties that alternative propellants for this product should provide, include:

1. Blade cooling properties;

2. Blade lubrication;

3. Grease solvent properties; and

4. Compatibility with the metal blades.

Hydrocarbon or Hydrocarbon Plus Flame Retardant--

According to an industry source, at least one company is currently in the process of converting its product to a hydrocarbon propellant system.[45/] Specific information concerning the hydrocarbon propellant system was not available. Therefore, it cannot be determined whether the system is pure hydrocarbon or hydrocarbon plus flame retardant. If the proper ratio of hydrocarbon to flame retardant was used, this propellant system could provide the properties necessary for this product line. A pure hydrocarbon propellant system could present a flammability and explosion problem. The use of water or certain chlorinated hydrocarbons as fire retardants would reduce this risk, but the electric shock hazard of any water-containing products or inhalation hazards of chlorinated hydrocarbons would have to be ascertained.

Carbon Dioxide--

According to another industry source, it is possible to use impact-filled carbon dioxide as a propellant system. The company spokesman indicated that their product will be impact filled with carbon dioxide as the propellant within 60 days.[44/] This alternative propellant will cool, lubricate and be compatible with the blades. It will not, however, provide grease solvent properties.

F-22 Propellant--

This propellant is considered by industry as a feasible alternative for F-12 if it becomes available.

Brush Application--

This product could be applied as a liquid directly to the blades by brush. This would be more time consuming, and the product may not come into contact with all surfaces of the blade.

Manual pump sprayer--

According to an industry source, this system is currently being implemented at one production site.[45/] The manual pump could meet all parameters deemed necessary except that it will not provide the rapid cooling effect observed when F-11 and F-12 are used.

Economic Considerations

Conversion to the alternative propellants or delivery systems (i.e., hydrocarbon or carbon dioxide propellants and the manual pump spray) will not result in increased consumer costs for this product.

MOISTURE REMOVAL SPRAY

Product Description and Utility

This aerosol product is utilized to remove moisture from electric motors, electronic equipment, relays, transformers, and other electrical equipment. These products are formulated with a variety of ingredients for moisture removal and rust prevention. Two common components are high flash point petroleum distillates and certain chlorinated hydrocarbons. Proper selection of the chlorinated hydrocarbons will result in a product that has no detrimental effect on the plastic components of the equipment.[40] One current formulation contains approximately 25% F-12 and 75% of a proprietary water removal solvent generally consisting of chlorinated hydrocarbon solvents plus additives.[33] The primary function of F-12 is that of a propellant, although it does lend a degree of nonflammability to the aerosol spray.

Principal users of these products are electrical repair personnel, electrical contractors, and others concerned with the restoration of water-damaged electrical equipment.[33] In general, the product is not used extensively by large electrical equipment manufacturers[47] or the general public.

Attempts to ascertain the quantity of F-12 consumed annually for this product were unsuccessful. One contract filler, currently using F-12, could not identify other manufacturers employing F-12.[33] Manufacturers of competitive aerosol products, using propellants other than the chlorofluorocarbons, could not identify any producers using F-12 for this product,[40,48-50] but some small formulators or packagers of this product may still use F-12.[48] It is estimated that the consumption of F-12 is rapidly declining because of the conversion by many companies to alternative propellant systems. In this regard, the removal of the chlorofluorocarbon propelled product from the market would have little, if any, adverse impacts on environmental quality and human health or safety.

Alternative Products or Systems

Hydrocarbon Propellants--

Many manufacturers are converting from F-12 to hydrocarbon mixtures as a propellant for this product.[33] This propellant does produce a flammable spray. However, one manufacturer has used this propellant without any added flame retardant for a number of years with no known adverse effects.[50] While it would not be advisable to use this product while the electrical component is operating and producing an arc or electrical discharge, this restriction is not a severe detriment to the utility of the product.[50] For those products that utilize a chlorinated hydrocarbon as the principal ingredient, the resultant spray should not have the flammability potential of a normal hydrocarbon propellant.

Carbon Dioxide--

Impact-filled carbon dioxide is currently used in at least one formulation consisting of a high flash point (175°F) petroleum distillate and methyl chloroform with added penetrants and inhibitors.[48] Under certain circumstances, the coarse spray produced by this propellant may affect the surface coverage and decrease the efficiency of the product. In some instances, this propellant may not dispense all of the active ingredient from the container before the pressure drops to an insufficient level.

Thermal Drying--

In this procedure, the water-damaged component is removed from the equipment and placed in a drying oven for moisture removal.[51-53] Some companies have walk-in ovens that can accommodate large electrical components.[51] An advantage to this method is that no chemicals are in contact with the component, thus alleviating any potential detrimental effect of the chemicals. The method is much more time consuming since the damaged part is removed from the system. For those instances in which removal of the part would not be possible or very time consuming, space heaters are often employed.[51]

Manual Pump Sprayers--

This type of sprayer is not in common usage and reportedly suffers from the lack of sufficient pressure to permit satisfactory moisture removal.[33]

Solvent Bath--

For certain applications with small parts, this may be an acceptable method. However, for situations requiring disassembly of the machine or instrument, the labor required would not make the method cost effective.

Brush Applications--

This method may be adequate for some applications. However, in most instances, there is insufficient access to the components to allow adequate moisture removal by this technique.

Compressed Air Sprayers--

A compressed air sprayer should be an adequate method for larger equipment or components. The quantity of product used by this method would likely be greater. However, since bulk quantities could be purchased, the overall cost should not increase appreciably. This would depend upon the care with which the product is applied.

F-22 Propellant--

F-22 could be used as an alternative propellant for most component systems if it were available. This propellant may have a detrimental effect on some component parts, but in general, would be acceptable.

Economic Considerations

There would be no economic impact associated with the use of hydrocarbon mixtures or carbon dioxide as a propellant system on consumers or users of these products. On the current market, both products are priced competitively with those products using F-12 as the propellant. The use of the bake-out ovens for thermal drying would likely be more costly due to the necessity for removal of the components.

ENGINE DEGREASERS

Product Description and Utility

This product is produced and marketed to industrial and commercial concerns as well as being available to the general public. Regardless of which portion of the market utilizes the product, its universal purpose is to provide a rapid and cost-effective method for the removal of grease from various types of surfaces without damaging the surface. Grease-free surfaces tend to improve the cosmetic appearance of areas and can help promote safety. In addition, grease-free surfaces improve the ease of accessibility for maintenance and repairs. For engines, specifically, use of a degreaser prevents grease buildup, which could reduce convective heat losses from the engine. A reduction in convective heat loss could, under certain circumstances, result in higher-than-normal engine operating conditions and internal engine damage.

Engine degreasers have various compositions, but three components are generally common to this product line: a solvent, a degreaser, and a propellant. The solvent is ordinarily a saturated or an aliphatic hydrocarbon.[54/] The degreaser is a grease emulsification agent.[54/] The propellant is either a nonflammable blend of isobutane and F-12[55/] or a hydrocarbon mixture.[54/] The primary function of the F-12/isobutane mixture and the liquifiable compressed gas is to provide a propellant system for the product, although the presence of the F-12 in the former may lend some degree of nonflammability to the product.

Approximately 12 to 15 million units of aerosol engine degreaser are produced annually.[54/] A standard unit is a 16-oz can. According to an industrial source, the percentage of these aerosol products containing F-12 as a propellant is very small. If one assumes that about 2% of the total amount of product uses hydrocarbon/chlorofluorocarbon mixtures as propellants, then an estimated 40,000 to 50,000 lb of chlorofluorocarbons (as F-12) may be consumed annually in the manufacture of this product line.[56/] These numbers are approximate because the propellant in question is a blend of isobutane and F-12. For the calculations a 50:50 ratio of hydrocarbon and chlorofluorocarbon has been assumed.

Removal of this product without replacing it with an alternative could affect safety. An increase in the incidence of accidents which could be attributed (directly or indirectly) to increased exposure to unsafe working surfaces might be possible if the product is removed and not replaced with an alternative. No known or potential direct impacts on human health or the environment should result if this product line is removed and not replaced with an alternative.

Alternative Products or Systems

Compressed Gas Aerosols--

Pressure reduction as the volume of the contents decreases is the major drawback for compressed gases other than carbon dioxide. In addition, compressed gas propellants would be inadequate to discharge the product in the case of inadvertent misuse of the product (e.g., inverting the can).

Carbon Dioxide--

Impact filling with carbon dioxide could be used to alleviate the pressure loss problem associated with compressed gases. Since this product line should not be an aqueous system, impact filling with carbon dioxide is one potential alternative propellant system.[48]

Hydrocarbon Aerosols--

Pure hydrocarbon propellants can provide the characteristics required for this product line.[54] According to an industrial source, the vast majority of aerosol engine degreasers currently marketed utilize this propellant system.[54] Hydrocarbons could, under certain circumstances, present a flammability and/or explosion problem. However, in view of the current market, this does not appear to present a serious problem.[54] Currently used fire retardant additives cannot be used to reduce the flammability or explosion risk, since they could quite possibly react with plastics and rubbers with which they might come into contact.[55]

F-22 Propellant--

If available this chlorofluorocarbon would be an acceptable alternative. No problems would be anticipated in converting from F-12 to F-22 for this product.

Brush Application--

By bulk (as a liquid) degreasers may be applied by brush. If the circumstances permit, the article in need of degreasing may be dipped in the degreaser. At least two companies market engine degreasers in bulk quantities.[54,57]

Manual Pump Spray--

In addition to brushing and dipping, these degreasers are applied by manual pump sprayers. This system allows the degreaser to be applied to hard to reach areas and equipment with average surface area.

Compressed Air Hand Sprayer--

This system is similar to the back pack sprayer utilized by some pesticide applicators. The system consists of a galvanized or stainless steel tank with a removable pump and a section of hose with a variety of nozzles. The degreaser is mixed before being poured into the tank. The pump is inserted

and locked into place, and the tank is manually pressurized. For manual pump sprayers and compressed air hand sprayers a wide range of nozzles, which allow the applicator to select the desired spray characteristics, are available.

Economic Considerations

Carbon Dioxide--

If impact-filled carbon dioxide would be an acceptable propellant, there should be little or no increased costs to the consumer due to the propellant system. With this system, the decrease in propellant costs (F-12 versus CO_2) would likely be balanced by the increased quantity of product in the container. Any cost incurred for conversion of the filling equipment may be passed on to the customer. However, the final product must be economically competitive with the current hydrocarbon propelled products.

Brush Application--

If applicable, this technique should provide a low cost means of application since the degreaser can be purchased as a solution, eliminating the cost of the aerosol container.

Manual Pump Spray--

Use of a manual pump spray should result in a cost either approximately the same as, or slightly less than, the F-12 propelled product depending upon the type of manual pump dispenser utilized.

Compressed Air Hand Sprayer--

For applications to large surface areas, these devices may be advantageous. The tanks are available in a variety of sizes and costs. A 2-gal. galvanized steel tank costs $25.79, while a 4-gal. tank costs $29.79.[58/] For stainless steel tanks, the 2-gal. capacity costs $44.79 and the 4-gal. $49.79.[58/] Since bulk volumes of the degreaser can be used, cost savings should be incurred with extended time usage on high volume consumption.

ELECTRIC SHAVER CLEANERS AND LUBRICANTS

Product Description and Utility

This product type is manufactured and marketed by several organizations.[59] A typical formulation consists of the active ingredient which is an alcohol and oil mixture, the propellant system which is chlorofluorocarbons-11 and -12, and the solvent which is a refined petroleum distillate. The product also contains a small percentage of a lubricant, such as palmitate or a silicone.[59,60]

The product is applied to the electric shaver after use to clean and lubricate the shaving blades.[59] Use of the product purportedly assists in maintaining the sharpness of the blades by keeping them lubricated and free of excess hair clippings.[59] The market for this product includes the individual consumer who uses electric shavers and low volume commercial electric shaver repair shops.[60] The product is marketed as an aerosol in 6-oz cans and as a liquid in 8-oz containers.[59]

F-11 and F-12 function as a propellant system and provide a convenient method to remove hair from the shaver blades.[60] In a 6-oz aerosol can, the propellant system accounts for approximately 90% of the total product.[60] For calculation purposes 6 oz will be assumed to be the standard size can. The annual production of this product type is estimated to be 1×10^6 units/year.[61] The ratio of F-11 to F-12 is 50:50.[60] According to MRI estimates, 2.58×10^5 lb of F-11 and 2.3×10^5 lb of F-12 are used per year in this product type.[62]

The removal of this product type from the marketplace should result in no adverse effects on environmental quality or human health and safety.

Alternative Products or Systems

Several propellant systems exist which could be feasible alternatives to F-11 and F-12 for use in this product type. The only national distributor for this type of product is currently in the process of converting to one of the alternatives.

Compressed Gas Aerosols--

Pressure reduction as the volume of the contents decreases is the major drawback for compressed gases. This is not a practical alternative for this product line.

Carbon Dioxide--

Impact filling with carbon dioxide may alleviate the pressure loss problem associated with other compressed gases. The high pressure of the propellant

would provide enough force to blow away the hair in the shaver blades. This system could be applicable as an alternative propellant for this product type.

Hydrocarbon Propellants[61]--

This product has been reformulated to utilize a hydrocarbon propellant. The new product has been tested by the national distributor on its electric shavers and found to perform in a satisfactory manner. A product containing a hydrocarbon propellant will be marketed during February 1978. Although hydrocarbon propellants normally present a potential flammability hazard, the prior testing has indicated that no problems of this nature should occur with their current electric shavers. No testing has been conducted on other makes of electric shavers.

F-22 Propellant--

F-22 should be a feasible alternative for this product type, if it becomes available.

Nonaerosol Method--

Excess hair can be removed from and a lubricant applied to the shaver blades by nonaerosol methods. Excess hair can be removed by using a small brush, followed by application of a lubricant and cleaner as a liquid.[59]

Economic Considerations

Substitution of a hydrocarbon propellant for F-11 and F-12 in this product type should result in little, if any, increased cost to the consumer.[61]

A 6-oz aerosol can of this product contains approximately 0.6 oz of active ingredient. The cost is $1.95.[59] This results in a cost of $3.25/oz of active ingredient. An 8-oz container of the product as a liquid costs $2.50 or 31.25¢/oz. If manual application is utilized the consumer can expect a cost savings.

AIRCRAFT DEODORANT SPRAY

Product Description and Utility

Aerosol deodorant sprays are used in aircraft cabins and holds to control undesirable odors from cooking, food decay, airsickness, excessive usage of aircraft toilet systems, and other sources. Without rapid treatment of odor problems, an increase in airsickness may occur on passenger aircraft. This product is also utilized on cargo aircraft for odor removal.

These aerosol products generally use a 50:50 mixture of F-11 and F-12 as a propellant system.[63/] The primary function of the chlorofluorocarbons is as the propellant and the nonflammability properties lent to the spray are secondary functions. It is estimated that approximately 110,000 lb of the two chlorofluorocarbons are consumed annually for this product.[63/] If an equal volume of mixture is used consistently throughout the industry, this would correspond to approximately 58,000 lb of F-11 and 52,000 lb of F-12. According to one industry source, this product is normally sold in 6-oz containers.[63/]

Aside from personal discomfort situations which may occur, the removal of this product from the market would likely have no adverse impacts on environmental quality and human health or safety.

Alternative Products or Systems

The inability of current manufacturers to utilize F-11/F-12 mixtures would likely result in attempts to utilize hydrocarbon-water mixtures or carbon dioxide as propellants for aerosol spray products or to utilize mechanical pump spray dispensing systems.[63/] According to the Materials Transportation Bureau of the Department of Transportation (DOT) rules and regulations, aerosol dispensers are not classified as hazardous materials and can be carried by an aircraft operator if authorized or required aboard his aircraft for its operation (Section 175.10).[64/] For any alternative propellant, prior testing would be required to assure that the material would not undergo reaction or affect any of the cabin components, such as the Lexan (polycarbonate plastic) windows.

Hydrocarbon Propellants--

Hydrocarbon-water-glycol mixtures of the type currently used for household room deodorizers may be acceptable alternatives. A spokesman concerned with rules and regulations for a U.S. airline stated that, as far as he could determine, the use of a product with this propellant system would be within the current rules and regulations.[65/] According to the Federal Aviation Administration,[66/] materials used on board commercial aircraft are governed by Department

of Transportation regulations. This propellant system could be utilized provided it is formulated and packaged in accordance with the regulations pertaining to products of this type (see for example Section 172.101, 173.115, and 173.300).[64/]

Carbon Dioxide--

Impact filling with carbon dioxide could be used as an alternative propellant system.[63/] However, this system produces a relatively coarse spray so that the effectiveness of the deodorizer may be impaired due to a decrease in the time the particles will remain in the air. It is unknown at this time whether this propellant will effectively dispense all of the active ingredient from the container before the propellant pressure decreases to an ineffective level. In addition, the internal pressure within the aerosol container may be above the level stated in the DOT regulation. Testing of this type of formulation would be necessary before a judgment could be made of its overall effectiveness.

Manual Pump Spray--

A product using this type of dispensing system could be employed for air deodorizers. The finger-type pumps would be applicable for relatively small areas. For large areas this method may prove to be physically taxing. A trigger-type pump can be adjusted to a fine spray, but generally the particle size would likely be too large to result in an efficient product.

Economic Considerations

The technology for hydrocarbon-water-glycol propelled products is well developed because of their extensive usage in household deodorizers; minimal problems should be incurred with this formulation. Since the current household products are priced competitively with the chlorofluorocarbon propelled products, no increase in prices should be passed on to the airlines utilizing this product.

If carbon dioxide should prove to be an effective alternative propellant, no increases in price should occur since this product will likely be in competition with the hydrocarbon-water-glycol propelled products. If the manufacturer has the product contract filled, no price increases should arise since filling costs are generally the same for F-12, hydrocarbon, or carbon dioxide propellants.

PRODUCTS FOR THE AIRLINE INDUSTRY

This area encompasses several products, specifically lubricants, corrosion preventives, solvent cleaners, dye penetrants, and touch up paints, which have specific usages in the airline industry. Airline spokesmen or anonymous sources in the airline industry state that most of the industry has reviewed their uses and employed alternative products wherever possible.[67-70] For all of these products, the general attitude appears to be that for products applied in the shop area under controlled conditions, alternative methods are available and can be used. These alternatives include hydrocarbon propellants. However, for usage on the aircraft itself the airlines are extremely reluctant to utilize any propellant which may present a flammability problem. This is due to the cost of each aircraft, which may be of the order of $25,000,000.[67] However, some anonymous sources stated that alternatives could be used for most applications.

Since it is not possible to discuss all of these products together, each will be discussed separately under the headings of product description and utility, alternative products or systems, and economic considerations.

Product Description and Utility

Lubricants--

These products are basically the same as those discussed under the heading of "lubricants" in a previous report.[37] They encompass both liquid (light petroleum oils) and solid (Teflon®, molybdenum sulfide, graphite, etc.) lubricants. Molybdenum sulfide is used more extensively than the Teflon®.[67] While none of the airlines contacted could provide figures regarding the actual quantities consumed by the industry because of the wide number of lubricants used, they stated that significant quantities of each type are employed. The chlorofluorocarbons employed and their functions are the same as described in in the previous report.[37]

Solvent Cleaners--

These products are the same as those described in the earlier report under the topic of electronic cleaners.[37]

Touch Up Paints--

This is the same product described in the previous report as spray paints.[37]

Dye Penetrant--

This product is employed to detect stress cracking in metal parts. Two different processes are employed for the use of dye penetrants; (a) the visible process and (b) the fluorescent process.

In the visible process, the penetrant is applied to the metal part to be inspected; this is followed by a cleaner to remove excess penetrant from the metal surface. A developer is then applied and any stress cracks appear as red lines on the white background of the dried developer.[68]

For the fluorescent process, the metal part to be inspected is dipped into a tank of water-soluble penetrant. Excess penetrant is washed from the metal surface with water and the metal part coated with dry developer powder in a tank. After exposure to air, the metal surface is viewed with a "black light" to detect areas of stress cracking.[68]

Aerosol forms of both of these products are available. Bulk solutions are more commonly used with the fluorescent process for economic reasons.[67] Although, the F-12 is used primarily as a propellant, one source indicated that the F-12 also provides good wetting properties for the penetrant.[67] Contact with two manufacturers of this product revealed little information concerning the quantity of F-12 consumed.[71,72] The aerosol product contains approximately 65% propellant.[71] Typically the remainder consists of a mixture of petroleum solvent and a phthalate with small quantities of the fluorescent dyes. Both manufacturers declined to discuss any information concerning the total annual industry-wide sales. Therefore, the total quantity of F-12 used in this product is unknown.

Corrosion Preventives--

This type of product is applied to form two different types of coatings. One type forms a dry, thin, hard coating whereas the other results in a soft, nondrying type of coating.[67,68] Both types are used as sealants against moisture, hydraulic fluids, brake fluids, or other liquids which could result in corrosion of metal surfaces. The aerosol products are used primarily for small applications or special control conditions.[67] For larger application, bulk solutions are employed.[67-69]

The aerosol products utilize a mixture of F-11 and F-12 as the propellant system.[67] The actual quantities employed for this specific application are unknown because of the wide industrial utilization of this product.

For all of these products, their removal from the market without replacement would have no effect on environmental quality. However, due to the rather unique nature of this industry, an assessment of the impact of their removal on human health or safety is beyond the scope of the present study.

Alternative Products or Systems

As stated previously, the applicability of alternative products or systems to deliver the same goods differs from one industry source to another. Some sources state that for certain applications, no alternatives exist at the present

time, while others, who wish to remain anonymous, state that alternatives can be used for most, if not all, of the present uses of the chlorofluorocarbon propelled products. The principal factor involved with most of the applications appears to center around the problem of flammability.

Touch Up Paints--

More progress has been made in the use of alternative systems with this product than with the others.[67] Hydrocarbon propelled aerosols can be and are being used in many applications, depending upon the specific conditions. For other applications, airless sprayers are being used with satisfactory results. Another source stated that nonflammability of this product is not really a strict criteria since the paint formulations are flammable and the use of a hydrocarbon propellant would result in little increased flammability.[68] Other sources stated that very few situations would occur where, with proper precautions, a hydrocarbon propelled product and/or an airless sprayer could not be used.[69,70]

Solvent Cleaners--

Alternative propellants or delivery systems for this product have been discussed in an earlier report.[37]

Lubricants--

Alternative propellants or delivery systems for this product have been discussed in an earlier report.[37]

Corrosion Preventives--

Alternative propellants or mechanical methods of application would be very similar to those described in a previous report for liquid lubricants.[37] Some variation in the efficiency of application of certain aerosol propellants may be anticipated because of the viscosity of the product. Although some current corrosion preventives are flammable, hydrocarbon propellants would probably be generally unacceptable because of the flammability potential. Testing would be required for any new propellant system to evaluate total product dispersal, spray patterns and characteristics, and the overall product acceptability.

Bulk solutions are currently used in conjunction with pressurized containers (e.g., garden sprayers, backpack sprayers, etc.) for large area applications. With the proper selection of nozzles, this system may be applicable for some current applications of aerosol products. Airless sprayers may be applicable for selected applications in which a thin film would be required. Some testing may be required to attain the proper viscosity for the operation of the sprayer.

Dye Penetrants--

Aerosols--Since the product consists primarily of a petroleum solvent plus a phthalate with small quantities of dyes, other aerosol propellant systems may be applicable. Impact-filled carbon dioxide may be an acceptable alternative if no formulation or shelf life problems are encountered with the potential formation of acidic by-products. Small amounts of moisture in the aerosol container will result in the formation of carbonic acid which may have a detrimental effect on the phthalate or the fluorescent dyes. The use of a wetting agent may also be required to provide good surface coverage. Recently, question has been raised concerning the efficiency of carbon dioxide propellant to dispense all of the product from an aerosol container. This potential method would require further testing before product acceptability could be established.

Hydrocarbon propellants would not be an acceptable alternative if the product is to be utilized in a situation where flammability would pose a significant problem.

Nonaerosol methods--Manual application of dye penetrants by brushing the solution onto a metal surface and removing the excess with a cloth is currently practiced, in certain applications, by at least one airline.[70] It would appear that other mechanical methods of application may also be acceptable.

One possibility may be the use of trigger-type pump sprays. If surface wetting would be a problem, then it may be necessary to incorporate a suitable wetting agent into the formulation. This potential change in formulation would require further testing to determine if compatibility problems may arise.

According to one industry source, airless sprays apparently will not work with the current bulk solutions.[67] However, this may be a problem of surface wetting. If this problem can be overcome, the method should be an acceptable alternative.

Economic Considerations

The economic aspects of solid lubricants, corrosion preventives (liquid lubricants), solvent cleaners, and spray paints have been discussed in a previous report.[37]

For dye penetrants, the use of impact-filled carbon dioxide as a propellant should not lead to any increased cost to the consumer. As with many other products, the decrease in cost due to the propellant is balanced by the use of more product in the formulation of the total aerosol system. The use of bulk solutions and a mechanical application method should, ultimately, lead to a reduction in costs. Initially, increased costs will occur because of the

purchase of portable sprayers. The rate at which the lower cost of the bulk solutions will overcome the initial sprayer costs will be dependent upon the volume of dye penetrant consumed.

CONTACT CLEANER/LUBRICANT

Product Description and Utility

This product is similar to the electronic cleaners employing F-113 and F-12 described in an earlier report[37] except that an additional component is added as a lubricant, preservative, and anti-corrosion agent. The primary purpose of the lubricant is the prevention of the formation of metallic oxides by simple oxidation or by oxidation due to atmospheric contaminants such as sulfur dioxide.[73] The product is typically used by repairmen for cleaning and maintenance of electrical and electronic components such as switches, relays, radio and television tuners, transmitters, timers, and many others.[74] In addition to civilian repairmen, it is also used in certain military applications.[75]

The cleaner/lubricant is produced by a sole manufacturer in two forms: (a) an aerosol formulation using F-12 as the propellant; and (b) as a bulk liquid containing either the pure lubricant or as a dilute solution in 1,1,2-trichloro-1,2,2-trifluoroethane (F-113). In the aerosol form, the components are approximately 8% lubricant package, 15% perchloroethylene, 42% F-113, and 35% F-12. The sole function of the F-12 in this product is that of a propellant. The manufacturer claims that a very fine spray pattern is required for the effective use of this product. The perchloroethylene is added as a solvent for the lubricant package to obtain good miscibility with the F-113 and is present in both the aerosol and bulk products.[75] This report will be concerned only with the use of F-12 as the aerosol propellant, and no consideration will be given to the subject of the applicability of F-113 as the cleaning solvent.

Based on information provided by the manufacturer, it is estimated that approximately 4,000 lb of F-12 are consumed annually in this product.[73]

For the product employed for use by civilian repairmen, the removal of the F-12 propelled product from the market would have no known adverse impacts on environmental quality or human health and safety.

Alternative Products or Systems

Hydrocarbon Propellant--

Considering the quantity of chlorinated hydrocarbon employed in the aerosol formulation of this product, a hydrocarbon propellant would appear to be an adequate alternative because the chlorinated compounds should lend a degree of nonflammability to the spray. In addition, this propellant would also satisfy the manufacturers requirement for a fine spray to preserve the effectiveness of the product. However, tests by the contract aerosol filler for this product show that the current formulation with a hydrocarbon propellant is flammable when sprayed across an open flame.[75] When the bulk liquid is placed in an

open cup and ignited, the liquid will flame momentarily.[75/] Because of the flammability characteristics, this propellant system would not likely be an acceptable alternative.

Carbon Dioxide--

The manufacturer has requested the contract filler to prepare test samples using carbon dioxide as the propellant. This propellant is used with the electronic cleaners containing only F-113, and if the containers are impact filled, no formulation problems should arise. However, the spray resulting from the use of carbon dioxide is more coarse than that obtained using F-12 and this may result in a reduction of the effectiveness of this particular product.

F-22 Propellant--

F-22 could likely be used as an alternative propellant system for most components if it were available. This compound may have a detrimental effect on some component parts, but it could prove to be acceptable.

Manual Pump Sprays--

In view of the manufacturers comment that the product works better when used in small amounts, manual pump sprays would probably not be a feasible alternative due to the rather coarse spray pattern produced and the large quantity of material dispensed.

Bulk Liquid Methods--

This product is sold in bulk quantities for application by cloth, brush, or cotton-tipped applicators. For many applications, these are a suitable method of application. However, in many electronic components, it is very difficult to manually apply a liquid because of the difficulty in gaining access to the component. If partial dismantlement of the equipment would be necessary, there would be increased labor costs.

Economic Considerations

As stated previously, this cleaner/lubricant is produced by only one manufacturer. The sales attributable to the aerosol product constitute approximately 50 to 60% of the total annual sales for this company.

If carbon dioxide should prove to be an acceptable alternative, no increase in consumer costs would be anticipated since the aerosol product is filled by a contract filler who normally charges the same price for filling with carbon dioxide as for F-12.

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